proaching it too close at an unfavourable moment, from ignorance of its true position, until too late to be avoided.

When the Medina anchored off the s.w. point of Serpent Island at the close of a N.E. gale, she found four vessels lying under shelter of the island, at about one cable from the shore, in 12 and 15 fathoms. The bottom is fair holding ground in that depth all round the island, and seems to consist of mussel-shells and mud, into which the anchor sinks. Arrian mentions that the island was a refuge for the mariner in stress of weather in the earliest days. Thus it is evident that, by the addition of a light upon it, the island is rendered doubly valuable to the navigation and trade with the Danube, and to this trade therefore the island is of special use and importance. It is true that vessels bound for Odessa may benefit by this light in rectifying their course; but to that trade it is not so much a necessity as to the Danubian, because Odessa has a high coast on either side, and has its sea-warning in the advanced and elevated light upon Cape Fontana in addition to its port lights. Therefore it is clear that to the trade of Odessa Serpent Island is not a necessity, although sometimes serviceable; for it must be borne in mind, in considering this question, that Serpent Island is not a danger, but Nature's sea-beacon, being high and bold, and by the addition of the light the position of the beacon is merely made as visible by night as by day at the greatest possible distance.

XI.—*Hydrography of the Valley of the Arve.* By Professor PAUL CHAIX, of Geneva, Corresponding Member of the Society.

Communicated by the SECRETARY.
Read, June 8, 1857.

HAVING last year given some time and care to the study of my country, under an hydrographical point of view, I collected as many of the existing documents as I could procure, and attempted to add to the scanty stock, some observations of my own on the basin of the Arve. Although, strictly speaking, that river flows mostly through the Sardinian territory, I thought it was too closely connected with Switzerland to be neglected, especially as it is more directly within my reach.

The river Arve is the most considerable of the Alpine tributaries of the Rhone, more from its size than from the extent of country it drains, which covers an extent of 385 square miles on the northern or right side of the river, and 386 on its left or southern bank; being a total of 771 square miles. Its boundary line winds along the crest of mountains over a length of 64 miles on the northern side and 93 on the southern. Of the total surface of the basin, 82 square miles are covered with glaciers and constant snows.

The number of tributaries is 16 on the right side and 17 on the

left; 11 of the number are formed from the snow and ice waters. The most important tributaries are—on the right the Giffre, with a course of 26 miles, and the Menoge, with one of 16; on the left side the Bonnant is 14 miles long, and the Borne 18: the Arve itself having a course of 65 miles.

Positions.	Height above the Level of the Sea.	Fall of the Trunk.	Length of the Trunk.	Fall per Mile.
	Eng. feet.	Feet.	Miles.	Feet.
The spring, near the village Du Tour ..	4277	..	..	..
Chamounix	3414	863	7	123
Saint Martin	1781	1633	16	102
Cluse	1587	194	10	19
Bonneville	1450	137	9	15
Mouth of the river Menoge	1387	63	11	6
Mouth, confluence with the Rhône	1222	165	9	18
		3055	62	50 average.
The Bonnant.				
Plan of Mont Jovet	6235	..	..	..
Nant Bourant	4520	1715	2	857
Notre-Dame de la Gorge	3900	620	$\frac{2}{3}$	910
Mouth, into the Arve	1886	2014	$9\frac{1}{4}$	214
		4349	12	362 average.
The Giffre.				
Bottom of the Combe, valley of Sixt ..	3811	..	..	..
Sixt (Abbey of)	2443	1368	6	228
Sixt (entrance of the valley)	2355	88	$1\frac{1}{4}$	70
Samoëns	2329	26	2	13
Tanninge	2115	214	7	30
Marigny	1568	547	8	68
Mouth	1535	33	2	16
		2276	$26\frac{1}{4}$	87 average.
The Nant, or brook of the Reposoir.				
Reposoir from the Carthusian convent to Scionzier	..	1994	5	400
The Borne.				
Great vg. of Bornand	4231	..	..	..
Lesser Bornand	2371	1860	6	310
Bonneville	1450	921	6	153
		2781	12	232 average.
The Menoge.				
Habère Lullin	2834	..	..	..
Bonne	1604	1230	$9\frac{1}{2}$	129
Bridge of Trebille	1387	217	$4\frac{1}{2}$	48
		1447	14	103 average.

The above table shows what is the slope of the river and of its tributaries—the latter presenting a more rapid fall than the main river. The only exception is found in the more even plain, through which the Giffre flows after it has issued from the valley of Sixt, through the deep and narrow chasm called la Tine.

The bed of the Arve is of a very irregular width, in average from 80 to 95 mètres, or 260 to 311 feet English measure, widening in some places, and after heavy rains, to about half a mile. One such reach is to be found, 3 miles long, above Saint Martin, and another of 12 miles below Cluse. Embankments have been raised in order to deepen and rectify the bed over an extent of 4½ miles above Bonneville, and along the last two miles of the course of the Borne. The bed is very much exposed to be divided by the accumulation of sands and gravels, which form in the middle narrow shoals of an elongated shape, called herrings. They have the inconvenience of throwing the current from the middle channel to each bank, encroaching upon cultivated lands, while it widens the bed by the formation of unproductive gravel banks; the more so as the main stream very seldom keeps to the same bank, but, on the contrary, is alternately thrown from the right to the left by every herring in succession. In those places where the banks of the river are steepest they are raised from 28 to 36 mètres (92 to 108 feet) above the level of the water.

The average temperature of water is 45° Fahr. (7° Centigrade). I found it on the 24th of July, at 1½ o'clock in the afternoon, at Bonneville, 56½° Fahr., while the air was 72° Fahr. Early in the morning, while the air was at 53° Fahr., I found the water of the Arve at 48½° Fahr. and that of the Borne at 50°. On the same day, at 11½ o'clock in the morning, I found the water of the river Giffre, at Marigny, at 13° Cent. (56½° Fahr.), while the air was at 71° Fahr. very much the same as the Arve. Observing the temperature of the Giffre, at the bottom of the valley of the Sixt, where it issues from under a deep bed of snow, I found it as high as 45° Fahr. It is true that before reaching that bed of snow they fell several hundred feet from the glaciers, being very likely heated in their fall by the contact of the air and by a very powerful sun.

I found this year the temperature, at the bridge below Carouge, was in the latter half of May 10·1° Centigrade in the morning, and 13·0° in the evening—in June, 11·1° in the morning, 13·7° in the evening—in July, 11·4° in the morning, 12·1° at noon, and 14·3° in the evening—in August, 11·0° in the morning, 11·2° at noon, and 12·0° in the evening—decreasing from the middle of the night to 9 and 10 o'clock before noon, and increasing even till 9 and 11 in the night.

From the fact that the waters of the Arve reach their highest level in the neighbourhood of Geneva from four to seven o'clock in the

morning (generally $5\frac{1}{2}$), it may be inferred that they are not more than 12 or 14 hours in running from Chamounix to the latter place. I found the rapidity was 1·8 mètres (5·9 feet) per second at Bonneville, in the middle of the channel, on the 24th of July. It, of course, depends very much upon the changes in the depth of the water. My most accurate and numerous observations have been made from a small wooden bridge, 620 mètres below the town of Carouge; the slope between that bridge and the stone bridge at Carouge being 6·2 feet (1·9 mètres) in a distance of 620 mètres, from 377·2 mètres to 375·3 mètres above the level of the sea. The mouth of the Arve into the Rhone is 372·7 above the sea, and 1600 mètres or 1 mile below my station.

I subjoin here the results of some of my measures of the rapidity of the stream, where greatest, with the corresponding levels of the waters, such as I read them on the scale :—

Height of the Water at the Scale.	Greatest Depth of the Section.	Rapidity in a Second.	
		Where Greatest.	Where Least.
Mètres.	English feet.	English feet.	English feet.
0·24	5·9	6·41	0·8
0·32	8·0	7·54	0·65
0·77	8·8	7·54	2·4
0·80	9·1	6·56	3·0
1·08	9·7	9·02	1·6
1·98	10·8	9·84	5·5

The rapidity of the Rhone, within the limits of our Canton, has been found 1·7 mètres (5·6 feet) at least, and 4 mètres (13·1 feet) at most; and at Lyons it is 2·50 mètres (8·2 feet) in a second. The amount of rain-water, collected by the basin of the Arve, may be said as unknown, having been as yet observed at Geneva only, where it is 33 inches yearly.

In order to know the body of water that flows in the bed of the river, I measured a transverse section of its bed by a sufficient number of soundings at the above-mentioned wooden bridge, where it is 243·5 feet wide, and I divided it into ten separate trapezoïd channels, of which I ascertained the volume by as many measures of the rapidity of the water at its surface, calculating the average rapidity by means of Arnott's formulæ.

It might have been expected that, having once taken accurate measures of the depth in each of the ten sections, when the waters were at their lowest level, I would have been spared the trouble of new soundings for every time I measured the rapidity of the water in order to calculate its volume, by merely adding to the depth of every partial section such increase of the height of the level which I read on the scale. Such, however, has not been the case, on

account of the great changes almost daily worked in the bed of the river by erosion and by the accumulation of shingle and sand. This accounts for my having found rates of rapidity and of depth in some of my partial sections, which but seldom kept pace with the changes in the general level. It is the only way in which I can explain those discrepancies.

The total body of water discharged by the river in one second :—

Height of the Water at the Scale. Mètres.	English Cubic Feet.
0·24	1,906
0·32	2,524
0·77	10,520
0·80	9,442*
1·08	12,002
1·98	17,367
2·50	22,397

The 0· mètres of the scale has probably been placed below the lowest level the waters ever subsided to ; but I have never seen them so low. When reduced to that lowest level, they still preserve a maximum depth of 1·56 mètres, or 5·1 feet in the bed. The highest level which I observed, namely, 2·50 mètres above 0· mètres, occurred on the 20th of October, 1855, at 1½ o'clock in the afternoon, after nine days of rainy weather. The river is known to have risen to more than 1 mètre above that point. Mr. O'Brien, a French engineer, found the produce of the Arve 38 cubic mètres (1341 cubic feet) in a second at the lowest state of the waters, and 354 cubic mètres (12,496 cubic feet) in summer. These two numbers may be considered as representing the regular volume of the river at the two opposite seasons of its low and high waters, when there are no rains in the country ; they differ as 1 to 9. Rivers which are fed from snow and ice waters seldom present a greater regularity in their volume. The Rhone, at its outlet from the lake of Geneva, has been found to give in its low state about 200 cubic mètres (7060 cubic feet), 700 cubic mètres (24,710 cubic feet) at its highest level, and 424 cubic mètres (14,861 cubic feet), when measured by MM. de la Rive, Colladon, and General Dufour, on the 24th of September, 1840. When we bear in mind that this river owes its changes of volume to the same cause as the Arve, its tributary, we see what is the regulating power of such a basin as the Lake of Geneva ; it lets out the waters of its emissary in much more regular quantities than it receives them from its tributaries.

When the summer is dry, the variations in the quantity of the

* The fourth measure, corresponding to a level of 0·80 mètres, is erroneous, from my having been but indifferently provided with the means of measuring it the time when I took it.

waters of the Arve are very regular: 21 readings of the scale have given 0·80 mètres for the average height of their level during the month of July; 45 readings have given 0·64 mètres for the average of August; 37 readings have made the average of September 0·55 mètres; 0·28 mètres for the first week of October; then came 11 days of rain, which raised the monthly average to 0·85 mètres. It has been only 0·33 mètres in November; 0·32 mètres in December; 0·42 mètres in January; 0·36 mètres in February; 0·30 mètres in March; 0·51 mètres in April. One single day of rain during the long droughts of a summer seldom raises the level of the water more than 0·2 mètres, if at all; the rain-water being then absorbed by the dry soil. But, when the rains set in for a few days, they become a much greater cause of increase of the body of water than any degree of heat working upon the snows and glaciers of the Alps. From a comparison of the monthly-average levels of the river, I find that the yearly average is 0·53 mètres, corresponding to the monthly-average heights of May and September. The body of water discharged by the Arve, when it is at that level, may be taken as a mean or average quantity of water in a second all the year round. This I have found to be 122·06 cubic mètres in a second, or 4308 cubic feet.

Having noticed that during a series of fine days the level of the water is invariably higher early in the morning than it is in the evening, I concluded, in accordance with former observers, that the greatest body of the waters from Chamounix are 12 or 14 hours on their way to the neighbourhood of Geneva. In order to know what may be the difference in the quantities produced by the glaciers during the night and during the greatest heat of the day, I compared a certain number (21) of readings of the level in the evening with an equal number of readings given by the scale in the early part of the morning, and found for the latter 0·69 mètres, while the average level of the former is only 0·62 mètres. I picked out only readings made during a long series of fine dry and warm days of July and August, taking care to exclude the colder and rainy months, when the difference is gradually reduced to nothing between the produce of the day and that of the night. Combining together the breadth of the river and its rapidity, both at the levels of 0·69 metrès and 0·62 mètres, I calculated that difference of level between the waters of the morning and of those of the evening amounts to a difference of 11 cubic mètres, or 388 cubic feet in a second; or, as there are during the longest days of the year eight hours in the day during which the rays of the sun act powerfully upon the glaciers and snows, the melted fluid produce of those eight warm hours may exceed that of as many cold hours by 316,800 cubic mètres, or 11,174,400 cubic feet; which produce amounts to 136,274 cubic feet for every one of the 82 square miles of snows and glaciers in the three valleys of Chamounix, Montjoie, and Sixt.

In order better to know what is the real body of water derived from the two first of the foregoing valleys by the Arve itself, I took separate measurements of its only important tributaries—the Giffre from the valley of Sixt, the Menoge from the valley of Boëge, and the Borne from the valley of the Bornands, at a time when the level of the whole Arve near Carouge was 0·77 mètres, and its volume 298 cubic mètres (10,520 cubic feet) per second. The body of the Menoge was found 1·9 mètres (57 cubic feet), and the Borne 4·7 mètres (166 cubic feet) in a second. Lastly, and on the same day, the 24th of July, I took very accurate measurements of the Giffre at Marigny, 2 kilomètres above its confluence with the Arve, dividing its wet cross-section into nine separate parts, of which I measured the width, the depth, and the rapidity. I found the whole width of the river 34 mètres, or 111·5 feet, its greatest rapidity 2·2 mètres (7·2 feet) in a second; the surface of its wet cross-section 19·7 square mètres, and its produce 36·52 cubic mètres in a second, or 1289 cubic feet. If I take from the body of the Arve, at Carouge, 298 cubic mètres, or 10,520 cubic feet, the sum of its three tributaries—the Giffre, the Borne, and the Menoge—together 43·12 cubic mètres (1512 cubic feet), I find the body of the main branch, the collected waters of the valleys of Chamounix and Montjoie, is 9008 cubic feet, or 255 cubic mètres in a second.

XII.—*Observations on the Water of Wick.* By JOHN CLEGHORN.

Communicated by Sir RODERICK I. MURCHISON.

Read, June 22, 1857.

I ENCLOSE a plan of our Bay made in 1814. You will observe that the sand is all on the south side of the river, and that Pulteney-town Harbour has been built on this sand-heap.

The south side of the Bay is the shallow or sandy side, the north the deep side. Below the sand there is a vast accumulation of large boulders, called on the plan "North Odd," "South Odd." These boulders form an incoherent pavement, partially covered with sand. On the north side there is a larger area occupied by them, and freer from sand than on the south side. Every puff of wind moves the sand; the boulders are set in motion by storms only, but, like the sand, they too are travelling to the south side of the Bay.

In the character of the stranded blocks on each side of the Bay there is a marked difference. Those on the north side, under the influence of high spring-tides only, are nearly all angular, and have been torn from the edges of the sunken ledges that margin its side; but on the south side the stranded boulders are nearly all water-worn, similar to those forming the "North and South Odd."